The Terrestrial Planet Finder (TPF)

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The Terrestrial Planet Finder (TPF) mission is a key element in the roadmap of NASA's Origins science theme and is slated to become the most ambitious NASA mission following JWST. The defining science goal for TPF is to understand the formation and evolution of planets and, ultimately, of life beyond our Solar System. TPF is now under study with work coordinated at NASA's Jet Propulsion Laboratory. The mission has a prospective launch date in 2015, with the observatory likely to be placed in an earth-trailing or L2 orbit and have a 5-year mission life.

Primary Science Goals

The primary scientific goal of TPF is the direct detection and characterization of Earth-like planets that orbit nearby stars; about 150 of the nearest stars will be surveyed out to a distance of about 15 pc, with low resolution (R ~20) atmospheric spectroscopy of selected candidates. The TPF mission will seek answers to the following questions:

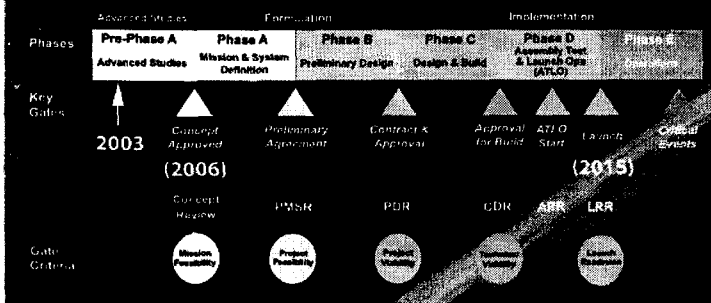
- Are there Earth-like planets in the "habitable zones" around parent stars where the surface temperature is capable of supporting liquid water?
- What are the compositions of atmospheres of terrestrial planets orbiting nearby stars? Is water, carbon monoxide, or carbon dioxide present?
- Are there atmospheric components or conditions attributable to primitive life, such as ozone or molecular oxygen, seen in the Earth's atmosphere?
- How do planets form out of disks of solid and gaseous material around young stars?

Optical and Infrared Biomarkers

The Science Working Group for TPF has determined that observations at either visible/near-infrared or mid-infrared wavelength bands would provide adequate information for the detection and characterization of Earth-like planets, because important signposts of habitability (and even of primitive life itself) exist in both bands.

Technology readiness, rather than scientific preference for any particular wavelength region, will probably be the determining factor in the selection of the final mission.

TPF is now in Pre-Phase A of the NASA Project Life Cycle



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Mission Concepts

TPF will be a technologically challenging mission regardless of the architecture that is ultimately chosen. The architecture concepts that appear most promising are visible/near-infrared coronagraphs based on large single telescopes, and mid-infrared interferometers (with multiple telescopes separated by 25 to 40 m or more). For the interferometers, both formation-flying and structually-connected designs are being considered.

Optical Coronagraphs

An off-axis optical telescope with a clear aperture having a width of at least 8 to 10 meters would have the necessary angular resolution to detect Earth-like planets. It must suppress the star light by a factor of ~10^{10} for the planet light to be detectable. The coronagraph would have a mirror with about 1 nm rms micro-roughness and ~5 nm rms at mid-spatial frequencies. The wavefront quality would be further improved with a high-performance deformable mirror, and innovative masks and pupil stops would be used to suppress stray light.

Mid-Infrared Interferometers

At mid-infrared wavelengths, nulling interferometer designs using three or more 3 to 4 m telescopes, located on either an array of formation-flying spacecraft or on a large structure, would be capable of detecting the thermal radiation emitted by Earth-like planets around nearby stars. The telescopes would have aperture diameters of ~3.5 m and would be separated by 25 to 40 m or more. Null depths of ~$1{:}10^{6}$ would be required to detect planet light. The whole observatory would be cooled to ~35 K.

Project Status

TPF is in the first stage (Pre-Phase A) of the NASA project life cycle, where the emphasis is on establishing top-level goals, science requirements, and the technological feasibility of the mission. Since August 2002, NASA and the European Space Agency have been formally collaborating to design a planet-finding mission that incorporates work from both TPF and ESA's Darwin mission.

Resources for Further Reading

Darwin/TPF and the Search for Extrasolar Planets, ESA SP-539, European Space Agency, Noordwijk, NL (2003).

Technology Plan for the Terrestrial Planet Finder, Edited by C.A. Lindensmith, Jet Propulsion Laboratory Publication 03-007 (March 2003).

The Technology Plan and other documents relating to TPF are available at http://planetquest.jpl.nasa.gov/Navigator/tpf_library.html

IAU Working Group Meeting on Future Large-Scale Facilities
22 July 2003, Darling Harbour, Sydney, Australia.

http://tpf.jpl.nasa.gov/